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FEASIBILITY OF URANIUM DEVELOPMENT IN THE HALIBURTON AREA

Economic Development Branch
Ministry of Treasury and Economics
October 1979

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THIS ANALYSIS IS BASED ON THE BEST AVAILABLE DATA,
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SUMMARY

INTRODUCTION

The Rare Earth Resources Company has applied to various regulatory bodies to seek clearance to develop their uranium properties in the Haliburton area. Initial plans include extraction of uranium ore, concentration on the site and transportation by truck to Madawaska mine southwest of Bancroft for milling. The Madawaska mill is operating 5 days per week, thus 2 days of milling capacity (1,500 tons per day) may be available. This spare capacity cannot be guaranteed for the life of the (potential) deposits.

I. Uranium Potential in Haliburton

- Uranium deposits in the Haliburton area are controlled by three groups:
  - Rare Earth Resources
  - Cam-Kerr-Dolores, and
  - Uranex.
- These three groups combined are known to have over 3.8 million tons of measured and indicated uranium-bearing ore above cut-off grade[1] worth some $250 million at current spot prices. Rare Earth Resources and Esso Minerals[2] hold more than 50 per cent of the ore, including the richest deposits. The Cam-Kerr group controls about one million tons of ore, including two past producing mines. Uranex deposits are of the lowest grade.

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[1] A "cutoff" grade of 0.05% (or about 1 lb./ton) has been chosen for this analysis; it compares to that used by the existing mine in the area (Madawaska). Overall, the three groups have more than 6.3 million tons of uranium bearing mineralization.

[2] Esso Minerals has been financing exploration and development by Rare Earth Resources including the current project in the Haliburton area, and currently holds 18 per cent of the equity in Rare Earth. Esso is continuing to finance the projects in order to increase its equity to 25 per cent.

- Total known ore bodies could be exploited in less than 9 years by a mill with a capacity of 1,500 tons per day (tpd) working 300 days per year. Such a mill could likely produce uranium at a cost of $30-35 per pound. The current spot price is around $43 per pound.

- Additional inferred reserves based on limited drilling and geological projections could double the life of the proposed operations.

- The direct employment created by one mining operation may be 60 to 100, but if all properties are developed, the figure may approach 200.

II. Markets

- The only currently producing uranium mines in Canada are located in Ontario and Saskatchewan. There is a possibilty that the Blizzard Lake mine in B.C. will receive approval following the scheduled environmental hearings. Ontario Hydro is a participant in the consortium developing this property.

- Although annual output of uranium from the Haliburton area would represent only some 6-15% of annual Ontario Hydro demand, most of these requirements are already contracted. Ontario Hydro shortfalls as presently estimated are not expected to be sufficient to absorb more than 15 to 40 per cent of the proposed Haliburton area output.

- The remainder of the market for Haliburton area uranium might be found with foreign firms, especially in West Germany and Korea. In addition, two new nuclear power plants are opening in late 1980 or early 1981 in New Brunswick and Quebec. They do not yet appear to have committed suppliers.

III. Development Options

- The Rare Earth Resources group may be the closest to opening a mine. Preliminary feasibility studies have been concluded and required licenses have been applied for.

- The Madawaska mill has surplus capacity at the present time. They have informed MNR that they are looking into the possibility of custom milling for Rare Earth. If Madawaska and Rare Earth reach agreement, the potential for a new custom mill will decline.

- Although custom milling by Madawaska for other producers is the lowest cost option, it could mean that marginal deposits such as Uranex do not develop.

IV. Conclusions and Recommendations

- A commitment from Ontario Hydro to purchase uranium from Haliburton area producers would assist in getting development underway.

- Since the three mining groups involved do not appear to be actively discussing the situation, the Treasurer should consider bringing the three parties together to discuss how future development in the area can work to their mutual advantage.

- A new mill is required in the area so that all ore deposits can be exploited for the maximum benefit to both the Haliburton area and to Ontario. Initially it could service one or two deposits and eventually it could mill ore from all the deposits.

FEASIBILITY OF URANIUM MINE DEVELOPMENT IN THE HALIBURTON AREA

I. INTRODUCTION

1. Mineral Potential in the Area

The Haliburton/Bancroft area in general is well endowed with a variety of metallic and non-metallic minerals. The area attracts not only prospectors, but also rock and mineral collectors.

At the present time, however, the area has only one major operating mine (Madawaska). This uranium mine is located some 8 km. southwest of Bancroft. In addition, there are various pits and quarries for sand and gravel, and several small quartz and marble quarries.

Over the near term, uranium has the most potential for development. Although various other metallic and non-metallic mineral deposits have been identified in the area, including flourite, molybdenum, nepheline-syenite, marble, thorium, and some base metals, most of these deposits are economically submarginal. Thorium deposits in this area are considered quite rich but the market for this metal is not yet developed.

2. Companies Involved

Uranium occurences in the Bancroft area have been known for some three decades. In the late fifties and early sixties, as many as four mines were producing uranium[1] in the area.

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[1] The term "uranium" is used loosely throughout the paper to represent yellow cake which is a yellow coloured powder with U_3O_8 as its chemical symbol.

(i) Producing Mines

The Madawaska Uranium Mine is now the only uranium producing mine in the area. It supplies markets in Italy and U.S. This mine resumed production as a result of collaboration between the Federal Resources Corporation of Salt Lake City and Consolidated Canadian Faraday Limited. Production resumed in August 1976 after 12 years of dormancy following a seven year productive life. The old mine had a 750 tons per day (tpd) capacity, which has been expanded to 1,500 tpd. About 400 persons are employed at this mine.

(ii) Past Producers

Faraday Uranium Mine: This mine is now known as the Madawaska Uranium Mine, described above. Faraday negotiated a contract with Eldorado for the delivery of Uranium worth $30 million in 1956. Production started in 1957 with a milling capacity of 750 tpd. which was increased to 1,000 tpd. Ore from other small mines in the area was also milled on these premises which closed in 1964.

Bicroft Uranium Mine: This mine/mill operation was the first in the Bancroft area and had a capacity of 1,000 tpd. Production at this mine started in October 1956, and ceased in mid-1963 following completion of delivery contracts. The mill was dismantled, but the original machine room shop is still in use by a small local company. The mine is now under Cam-Kerr control.

Dyno Mine: This mine, located some 25 km southwest of Bancroft, produced uranium for a brief period only. The mill had a daily capacity of 1,000 tons. Production from this mine started in May 1958 and was suspended in April 1960 following arrangements with another producing mine to fulfill Dyno's contract obligations. This property is now controlled by the Cam-Kerr group.

Greyhawk Uranium Mine: Following receipt of a letter of intent from Eldorado in 1956, the company mined ore worth over $20 million which was trucked to Faraday in 1957 and 1958 for milling and finally delivered to Eldorado.

(iii) Non-Producing

Most of the known non-producing uranium deposits are in Cardiff, Monmouth and Cavendish Townships, and are controlled by three groups: (i) Rare Earth Resources, (ii) Cam-Kerr-Addison and Dolores (Cam-Kerr group), and (iii) Uranex.

3. Type and Grade of the Known Deposits

The three major groups combined are known to have over 6.3 million tons of uranium bearing mineralization averaging some 1.114 pounds per ton for a total of 7 million pounds of uranium. At the current spot price of $43.00 per pound of uranium, these known deposits hold some $300 million worth of $U_3 0_8$, if all of it is recovered. But if a cutoff grade of 0.05% (1 lb./ton) similar to that of Madawaska is chosen, then a body of 3.8 million tons remains with an average grade of 0.076 per cent. In other words, these ore bodies would contain 2,885 tons or 5.77 million pounds of uranium valued at $248 million.

Rare Earth Resources holds more than 50 per cent of known uranium deposits in the area. These reserves are confined to seven separate zones in 3 townships. Major properties of this group include Halo, which has two adits, one internal shaft, one raise and two good access points. Their Rare Earth property (formerly Blue Rock) also has a shaft and an adit. Cavendish deposits are relatively less developed.

Moreover, Esso Minerals Canada holds options on the Canadian All Metals and Mandarin properties, covering some 2,000 acres of marginal uranium prospects, now under active exploration. Northern Nuclear Mines holds an undeveloped sub marginal deposit estimated to contain 0.5 to 1.0 million pounds of uranium.

Total uranium oxide recoverable from the Rare Earth Resources and Esso Minerals deposits may be as high as 12 million pounds.

The Cam-Kerr Addison and Dolores group has about one million tons of ore containing some 1.25 million pounds of uranium, all above the 500 foot level with the potential for more ore below the 500 level.

Their control over some of the past producing mines makes these deposits relatively attractive from a development point of view.

The third company of note in the area is Uranex,[1] which was formed by the amalgamation of two companies, Powerex and Landair. Current known deposits of this company include some 2,000,000 tons of pegmatite containing an average of seven-tenths of a pound of uranium per ton of ore, (or 1.4 million lbs. of uranium) which is the lowest grade deposit in the area. This includes, however, some 400,000 tons ore containing 1.5 lbs./ton. Under current conditions, only the latter 400,000 tons containing 600,000 lbs. of uranium may be recoverable.

The size of the ore bodies listed above can only be used as a rough guide because exploration and changes in market conditions can influence this data.

4. Exploration Efforts

Exploration for uranium is ongoing in the area. All the companies listed above, including the producing Madawaska Uranium Mine, are actively engaged in various stages of exploration and/or development.

The commitments under the Mineral Exploration Assistance Program for the Eastern Ontario area are heavily weighted toward uranium mining. Ten out of the 15 approved applicants for fiscal year 1979-80 relate to uranium exploration programs in the eastern Ontario area.

Usually the size of an ore body increases with either new finds or better identification of the existing bodies. This results in continued revision to the estimated metal content and the life of the ore bodies.

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[1] Uranex also holds about 2 million tons of 12-18 per cent fluorite which is uneconomical at current prices of fluorite.

Changes in market conditions also influence the size of an ore body. An increase in the price of uranium will result in some sub-marginal mineralizations becoming economic ore bodies. This is well illustrated in the fact that in 1969, Madawaska Uranium Mine reported 1 million tons of ore assaying 0.144 per cent uranium. Between the time Madawaska resumed operations in August 1976 to the end of 1978, the company had already milled some 700,000 tons of ore. In addition, the known ore reserves now are considered sufficient to support production at current levels through to at least 1985. Thus the ore reserves must be estimated at about 2.8 million tons more, i.e., three times the estimates made some 10 years ago.

5. Infrastructure and Labour Force

Roads: The existing network of public roads and highways is considered very good by conventional mining standards in Northern Ontario or elsewhere in the world. However, certain portions of roadway may need upgrading to accommodate higher volumes of heavy truck traffic. Moreover, some small roads linking private uranium bearing properties to the provincial highways may be required.

Water and Hydro: The supply of water in the area is generally abundant, but no reliable comments can be made about the adequacy for a specific mill because a definite mill site has not been determined. There is no shortage of water at either the first or second potential sites selected by Esso Minerals. The electric power required for a mine-mill complex can be provided by the existing system with minor modifications.

Labour: There is no shortage of unskilled labour in the area. According to Treasury estimates, about 325 persons are currently unemployed in the Haliburton area. While some skilled labour is locally available, local highly skilled labour is generally unavailable.

A new small operation by the Rare Earth group may employ as many as 60 to 100 persons in the first year of its operation. If all the three groups were to start their mining-milling operation simultaneously, new direct jobs could

approach 200 in the Haliburton area. A large proportion of required staff could be trained on the job. There are various training programs such as Canada Manpower Industrial Training Program (CMITP), and Ontario Career Action Program administered by Sir Sanford Fleming's Northern Campus in the Haliburton area. If a concerted effort is made by the industry and the government, manpower needs can be met "locally" with the help of programs mentioned above. A breakdown of the labour situation in Haliburton is shown in the Appendix.

6. Recent Developments

A meeting was held in March 1979 of Economic Development Branch staff and representatives of Esso Minerals to discuss their plans and associated problems in the Haliburton area. The key points which emerged from the meeting were:

- The Mining Corporation of Canada was hired by Esso on behalf of Rare Earth Resources to conduct a pre-feasibility study. (The cost of a mine and mill has been reported to be $12-14 million in 1978 dollars.)
- Obstacles to the project include:
    - numerous uncertainties and hurdles regarding regulations and associated costs still exist;
    - market conditions for uranium are uncertain;
    - a custom mill in the area is unavailable.

During May, a similar meeting was held with representatives of Uranex. Almost all the points previously raised by Esso resurfaced at this meeting.

In mid-July, Mr. Leon LaPrairie of Rare Earth Resources contacted the Ministry of Natural Resources with the information that:

- Rare Earth wishes to establish a mine and a mill in the area;
- Cam has similar plans and these two companies may work together.

The Northern Miner of July 12, 1979 in quoting Mr. Harbinson, the President of Cam Mines, stated that Cam might consider a joint mill with Amalgamated Rare Earth, but will continue to hold title on its own properties.

The Haliburton County Echo of August 1, 1979 had a front page item about a Rare Earth study regarding a uranium mill at a possible cost of \$4 to \$12 million, and a potential new employment of 60 to 80.

The recent flurry of news reports on possible uranium developments in the Haliburton area gives some indication of future potential. Many of these reports may be purely speculative.

II. MINING AND MILLING TECHNOLOGY AND COSTS

1. Existing Uranium Mining Operations in Area

The method of mining may vary from deposit to deposit even under comparable host rock conditions. Therefore the cost of mining cannot be predicted accurately without proper studies by mining engineers. Moreover, use of an upgrading concentrator or changes in host rock composition can alter cost estimates radically. The milling process and related costs may be relatively easier to predict, but overall the estimates are only preliminary.

Some generalized assumptions can simplify the process of cost estimation. One of the key assumptions is that the general mineralogy of the area is such that a process similar to that of Madawaska can be employed at the new mine-mill complex. (Details of the milling process may be found in the Appendix.) Technological developments, and changes in regulations related to mining, milling and disposal of waste can change the cost structure substantially. No efforts have been made to incorporate these variables in the cost estimates. These assumptions pose limitations on the analysis, but are unavoidable.

Relevant data about Madawaska's operations available from published sources are included in Tables 2 to 4. Table 2 shows the all-inclusive cost of uranium production at $27.95 per pound in 1978, which is only 4¢ per pound above the 1977 figure. The total cost of mining and milling one ton of ore declined from $41.70 in 1977 to $40.71 in 1978. It is anticipated that per ton costs of ore milled will decline even further with an increase in the production rate. Table 3 shows that a 1.3 per cent improvement in the grade resulted in a 2.7 per cent change in the recovery of uranium. The cost of the mining is a very large component of the total cost, accounting for about 66 per cent, excluding interest expenses and mining tax (Table 4). Milling costs are about 24 per cent of the total, and administrative expenses are about 11 per cent, on the basis of 1978 data. Thus, mining costs, which are difficult to predict, form a very large proportion of the total costs. Variations in this and other component costs could create difficulties for overall cost estimates.

The cost of Madawaska's existing mine-mill complex may not be a true representation of current costs because these facilities were built over 20 years ago, and were brought back into production at relatively moderate cost. Therefore, it is essential that only the operating costs be isolated. If amortization costs of a new mill are added to the operating costs on a per ton of ore or per pound of uranium basis, then fairly reasonable estimates of total costs per ton are available. Table 5 shows that the total estimated operating costs at Madawaska for 1978 are $29 per ton of ore processed or $19.91 per pound of uranium produced.

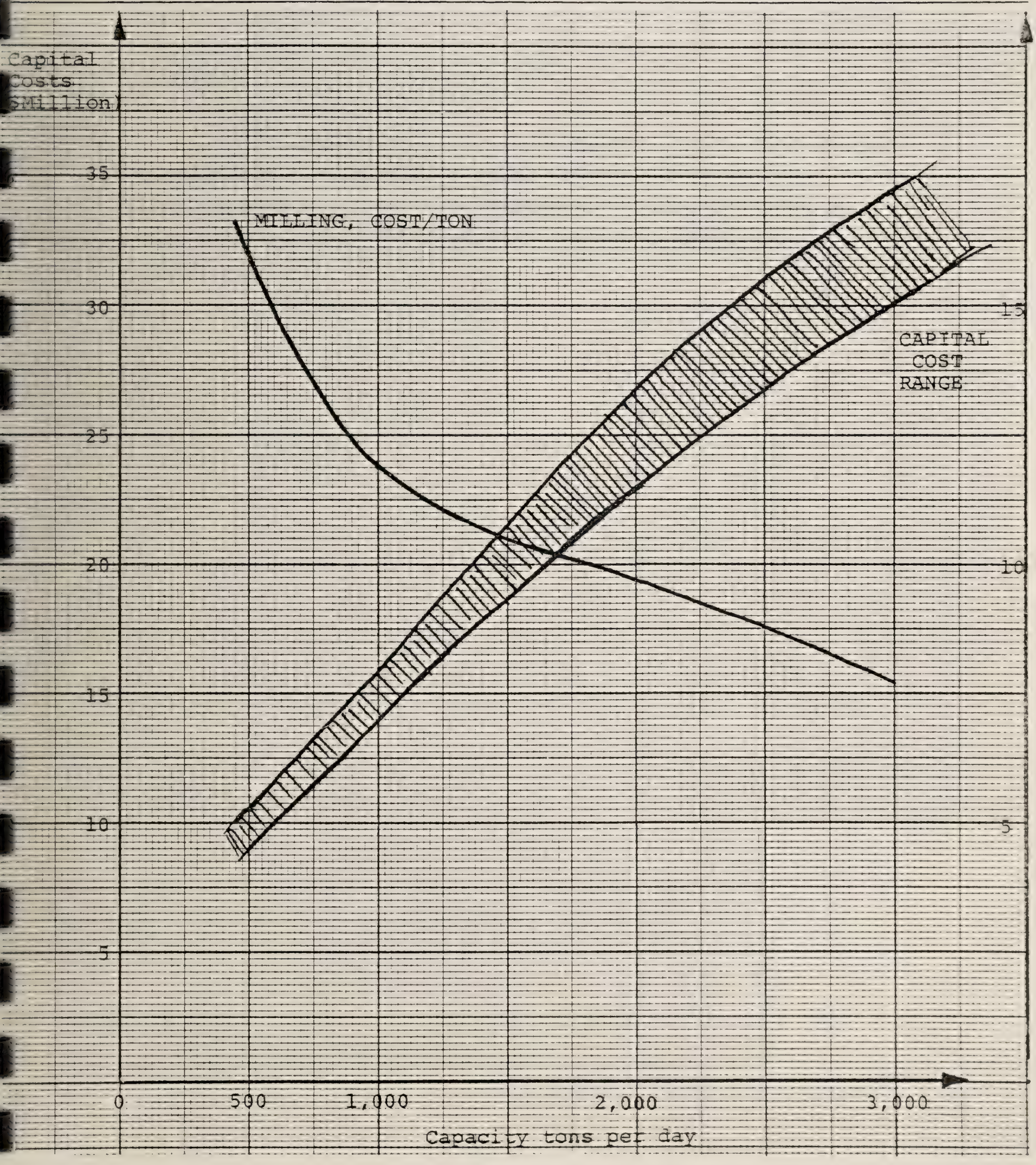
The capital cost of a mill rises with the milling capacity, but not in the same proportion. For example, the cost of one ton of daily milling capacity may decline from $18,000 for a 500 ton plant to $10,000 for a 3,000 ton plant (Table 6. Note that this relationship is shown for illustration purposes only). At the same time, average direct operating costs per ton decline as the size of the mill rises (Graph 1). The trade off in decision making is between the following: a large mine-mill with a high capital cost and high amortization expense but a lower per ton operating cost versus a smaller, low cost mine-mill but higher per ton operating costs.

Total known ore bodies in the area containing 3.8 million tons can be exploited in 8.5 years by an operation of 1,500 tpd working 300 days in a year. This life can be reduced to 5 years by doubling the capacity or increased to 17 years by reducing capacity to 750 tpd. Similarly, changes in the average number of days of operation per year can influence the life of a mine. The life cycle of an ore body, in essence, determines the amortization costs of the associated mill by providing the number of years of operation over which the loan may be amortized. Of course, interest rates etc. also influence costs (Table 7).

Another point that must be taken into consideration is the fact that a decline in ore grade usually results in a larger required feed to the mill to obtain a given amount of uranium. Moreover, the percentage of uranium that can be recovered usually drops as the ore grade drops; therefore, the cost of uranium per pound will rise more than proportionally with a drop in uranium grade. A decline in uranium grade from 0.07 per cent to 0.04, i.e. a drop of

ACID LEACH, COUNTER CURRENT DECANTATION, AND FIXED BED ION EXCHANGE, MILL COSTS 1978

Graph 1



Source: "Today's Uranium Milling Costs", by Robert B. Coleman, Mining Engineering, October 1978, p. 1428.

42.8 per cent associated with a 10.5 per cent drop in the recovery rate results in a 95 per cent increase in per pound cost of uranium in our hypothetical case (Table 8).

The final decision on the size of the operation involves numerous other variables such as the market for uranium now and in the future, nature of the sales contracts signed and technical problems of mining and milling, but the most likely size for a mill would be 1,500 tons per day operating as many as 7 days a week.

III. MARKET ANALYSIS

1. Characteristics of Uranium Market

The market for uranium has various distinctive features which set it apart from other commodities. This is because uranium is a strategic metal under government control which is in competition with oil and coal as a source of energy. Uranium compares with these traditional sources in the following ways:

- One ton of natural uranium contains the energy equivalent of 10,000 tons of oil or 14,700 tons of coal;

- In terms of costs (1977 estimates) it would cost 10 times more for feedstock if oil is used as fuel or 7.5 times more if coal is used as fuel instead of uranium to produce the equivalent amount of electrical power. Since the price of oil and coal have risen substantially in the past two years, this difference may be even higher.

- Low transportation and storages costs are illustrated by the fact that all the uranium produced in 1977 in the world would fit in a cube of 11.5 meter side.

These unique features play an important role in both the demand as well as the supply of uranium. The demand for uranium is influenced by:

- general growth rates of the economy which determine energy usage;
- social acceptance (or rejection) of nuclear energy;
- uncertainties related to the availability and price of oil;
- pollution and other risks of alternative energy sources such as coal;
- acceptance of fast breeder reactors.

The supply of uranium, on the other hand, is influenced by the following:

- Adequate proven ore bodies supplemented by continued exploration;
- The costs of production which includes availability of labour, capital, environmental and other regulatory costs;
- Ease in obtaining a long term supply contract at a price which provides adequate spread between the costs and the price;
- Socio-political stability of the country where buyer is situated and in the host country;
- Minimum uncertainties regarding regulations and tax laws.

2. Current Uranium Market

Due to certain recent events such as the accident at the Three Mile Island nuclear power generating station, and the movie, China Syndrome, demand for uranium has suffered a setback, at least temporarily. The long term impact of this accident is still being debated with arguments for and against. Some say that the dangers of nuclear energy are greater than anticipated, and that one day a reactor could melt down. Others say that the safety record of nuclear energy is proven by this accident. In spite of gross human and technical errors, not one person has died in some 30 years of nuclear power generation programs. No other industrial activity has such a record.

Interplay between these factors has baffled and divided uranium experts. The short term market is being called a buyers' market. The price of uranium as quoted by the Nuclear Exchange Corporation has declined from $43.25 to $42.70 in two consecutive months. This is an insignificant percentage (1.3%) relative to most other metals, but is the first time such a consecutive drop has occurred since July-August 1971. This consecutive decline is considered significant by some. Another indication of the vulnerability in the uranium market is the fact that the Tennessee Valley Authority (TVA), a U.S. government-owned utility company, is attempting to abrogate unilaterally its 17 million pound uranium supply contract with Rio Algom. The uranium was to be supplied over the period 1979 to 1990.

3. Uranium Buyers

(i) Ontario Hydro

A uranium mine is usually considered to be a captive mine. A new mine is usually not brought into production unless it has a supply contract for a reasonable length of time. An Ontario based new uranium prospect would obviously try to get a contract with Ontario Hydro, the largest single consumer of uranium in Canada, and perhaps the world. Therefore, it may be useful to analyze the potential for a uranium contract with Ontario Hydro.

An expert at Ontario Hydro summed up Ontario Hydro's latest requirements as follows:

1979-1981 Small quantities of uranium required (approximate needs = 1 million pounds).

1981-1988 The demand forecasts are being revised almost continuously because of uncertainties regarding electricity usage. At present, no major requirements of uranium are foreseen for this period. Small sporadic requirements are still possible. The Ontario Hydro forecasts published earlier this year state, "in the period 1980-1990, the Ontario Hydro uranium demand exceeds the contract supply and supplemental supplies will be required."[1]

Ontario Hydro released a report entitled 1979 Review of Generation Expansion Program, March 1979. According to this document, Ontario Hydro has surplus supply from contractors for 1979 and 1980, but in 1981 will need about 150 megagrams of uranium (about 330,000 pounds).

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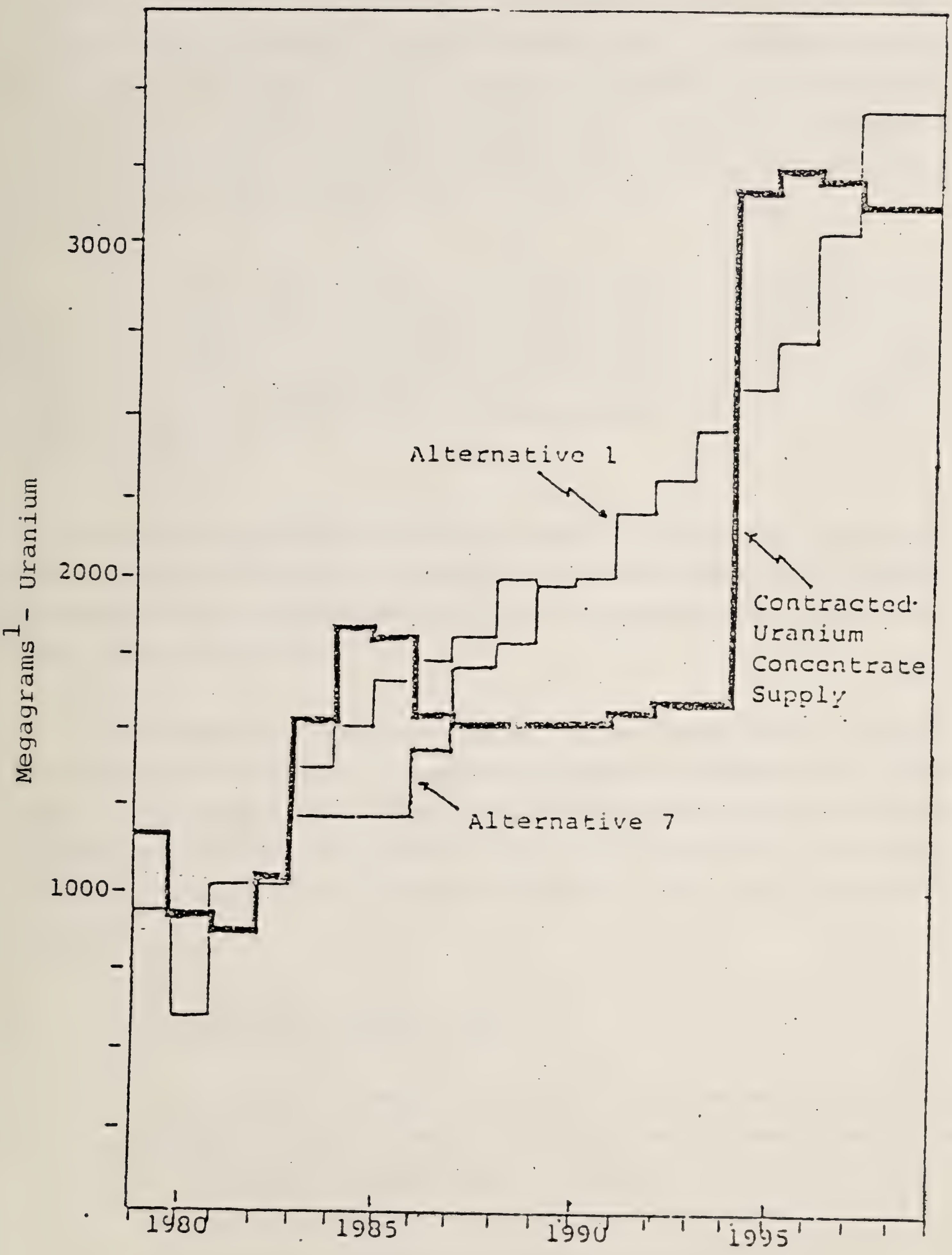
[1] Ontario Hydro, 1979 Review of Generation Expansion Program, March 1979.

NUCLEAR FUEL REQUIREMENTS AND CONTRACTED SUPPLY

Graph 2



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1. 1 Megagram = 1,000 kg. = 1 ton = 2204.6 pounds.

Ontario Hydro, 1979 Review of Generation Expansion Program, March 1979.

Also in this document is a graph which would seem to indicate that Ontario Hydro has a potential cumulative shortage of 1,130 tonnes (2.5 million lbs.) of uranium over the next 20-year period. (Table 9) This is equivalent to an average of some 125,000 lbs. per year over 20 years. It is probable that the difference in the above figures may be caused by the fact that (i) Ontario Hydro is revising their medium and long term demand estimates almost continuously, and (ii) Ontario Hydro borrowed uranium from UCAN in the past, and is considering retiring this debt.[1]

The annual level of economic output of uranium from the Haliburton area can vary from 289,000 lbs. to 650,000 lbs. depending on the size of the mill and the number of days of operation. The most likely range of uranium production is 289,000 pounds to 541,000 pounds (131-245 tonnes) per year from all deposits in the area (Table 10).

The potential production from these properties is higher than the average annual anticipated shortages at Hydro. But since these properties in Haliburton are unlikely to start production within the next two years, Hydro's requirements might change by that time.

The uncertainty regarding Ontario Hydro's requirements is further increased due to its interest in the Blizzard property in Kelowna, B.C. This property is to undergo public hearings under a Royal Commission of Inquiry into Uranium Mining which is to study environmental and other issues. If the project proceeds, Ontario Hydro's uranium requirements from other sources may decline.

(ii) Alternatives to Ontario Hydro

The potential production rate from the Haliburton area would be modest enough such that all output could be purchased by one large utility company to supplement its contracted supplies. For example, total annual production from this area can provide only 6 to 15 per cent of the average annual requirements of Ontario Hydro (4.3 million lbs.).

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[1] A company in need of uranium for a short term can usually borrow it, but has to pay interest charges on the basis of a predetermined price of the metal.

Other domestic utility companies could be considered potential buyers. At present, one nuclear power reactor Point Lepreau, is under construction in New Brunswick, and another one, Gentilly 2, in the Province of Quebec has been shelved. These units have a design capacity of 600 mega watts. Units of this capacity require some 90 tons of uranium annually at 80 per cent of capacity utilization. The New Brunswick reactor is expected to start operation by 1981. According to available information, no supply contracts have yet been signed.

As well, there may be potential foreign buyers. The demand for uranium from foreign sources, in particular, West Germany and Korea, has been reported as fairly strong. Although export of uranium requires federal approvals, export to nations which have signed a non-profileration treaty is not expected to present difficulties.

At present, some 180 nuclear power plants are under construction in the world (excluding Canada), as compared to some 210 in operation. Thus, this export sector may provide a strong alternative to domestic utility sales. (Table 11)

Other possible sales avenues include: (i) sales through an independent uranium broker such as the S.M. Stoller Corporation of New York, or (ii) arrangements through an exchange such as the Nuclear Exchange Corporation (NUEXCO). Some of these agents purchase small lots of uranium to put together large lots for major utility companies.

IV. ALTERNATIVE SCENARIOS FOR URANIUM DEVELOPMENT

A wide range of possibilities exists for uranium development in the area. At one extreme, all mining companies could have an operating mine and mill, and at the other extreme, no development could take place. All the possible options are listed in the following matrix.

OPTIONS FOR DEVELOPMENT

	Number of New Mills			
Number of Mines	None*	1	2	3
1	X	x	-	-
2	X	X	X	-
3	X	X	X	X

* Use of milling facilities at existing Madawaska mill.

To arrive at the most probable option for development in the area, all options which are not least-cost and highest-return should be discarded.

The first option to be discarded is that of 3 mines and 3 mills. This is because of the small size of deposits held by one of the three companies. Similarly the option of two mills is highly unlikely because of tonnage. Thus the likely options are either one mill or no new mill, each with up to 3 mining operations. Before discarding any other options, it may be useful to examine recent activities by the companies in the area.

I. Rare Earth Resources

Most news reports on Rare Earth Resources suggest that a new mining project is being developed in the Bancroft area. The cost of this project is quoted in the $4 to $12 million range and it is suggested that by 1981, production will have started from these properties. Most of their work has been directed towards obtaining various permits and licences. The group has applied to:

- The Atomic Energy Control Board;
- The Ministry of the Environment and the Ministry of Natural Resources.

Currently Rare Earth Resources is in the process of negotiating a custom milling agreement with Madawaska. The ore would be extracted from the following three sites in the following order:

1. Halo property located in the northwest portion of Cardiff Twonship (Wilberforce area);
2. Rare Earth No. 1 and 2 (old Rare Earth and Blue Rock properties) in Monmouth Township;
3. Cavendish property, close to Catchacoma Lake in Cavendish Township.

The company is holding discussions with Ore Sorters (Canada) Limited to examine the possibility of using a concentrator to upgrade the ore prior to further processing.

Preliminary feasibility studies by the Mining Corporation of Canada show favourable rates of return on both a 500 tpd. or 750 tpd. mill (assuming uranium at $49.00 per lb.). The price of uranium, tonnage and grade of ore, as well as the use of one-sorting equipment, may alter these rates of return substantially.

On the basis of these favourable preliminary reports, it may be concluded that at least one Rare Earth Resources mine may be developed in the area in the near future.

2. Cam-Kerr-Dolores Group

The Cam-Kerr-Dolores group has not made any public announcements about their development intentions. However, news items have appeared:

- The Northern Miner, July 19, 1979, states: "Cam Mines is trying to raise the necessary capital so it can play a dominant role in the development of its Bancroft area interest. This interest could involve joint ventures with other viable producers in the area."
- The Northern Miner, June 14, 1979, notes: "A future expansion of $12 million for milling facilities is not far-fetched and this would undoubtedly involve planning to do some custom milling for other producers in the area."

All other unofficial indications are that the Cam-Kerr group is very active in the area, and may be in contact with Rare Earth to develop a single mill. Both groups have clearly indicated that a catalyst is required to start action in the area.

3. Uranex Group

The Uranex group is monitoring the situation with keen interest because:

- they hold a large tonnage of low grade material including some 400,000 tons of marginal material; and
- Their properties are centrally located.

It is unlikely that this project could proceed in the absence of the other two. These properties, by virtue of their substantial tonnage of uranium deposits, can, however, increase either the life span or the size of the mill, thereby reducing per ton operating costs for every partner if a consortium is formed.

Mill Options

If no new mill is built in the area, then the existing mill at Madawaska may be approached to process ore from the other mining ventures. It is our understanding that:

- Madawaska has approached MNR for help in clearing hurdles to custom milling.
- If Madawaksa tries to accommodate custom processing, they will have to use tailing pile number 1. It is not clear whether they will be able to get permission to use this pile especially since it is suspected to be the cause of radon gas in a nearby housing subdivision.

At the present time, Madawaska has a maximum free milling capacity of 3,000 tons per week. Therefore, if Madawaksa is selected as the site for custom milling, ore from at most one mine will be used. Thus, the other two deposits may not be developed for a long time or they may never be developed.

The option of a new mill of about 1,500 tpd. capacity is most desirable in the area so that all ore deposits can be exploited for the maximum benefit to both the Haliburton area and to Ontario. Initially it could service one or two deposits and eventually it could mill ore from all deposits.

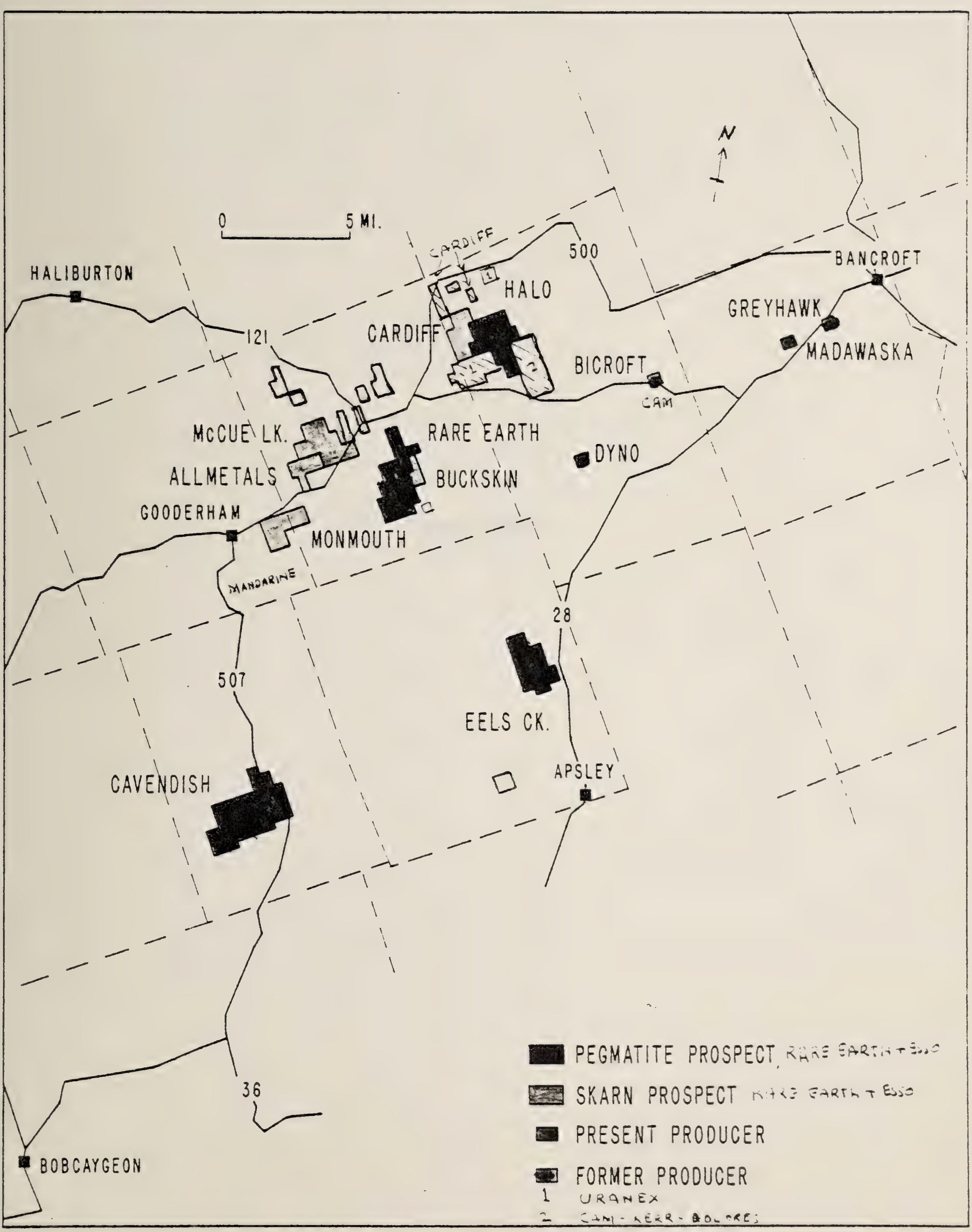
V. CONCLUSIONS AND RECOMMENDATIONS

The conclusion of this study is that a new mill is required in the area so that all ore deposits can be exploited for the maximum benefit to both the Haliburton area and to Ontario. The Haliburton region especially would benefit from the increased jobs and income which mining development would bring.

The government could play a major role in coordinating development in the area. Since the three mining groups involved do not appear to be actively discussing the situation, the Treasurer should consider bringing the three parties together to discuss how future development in the area can work to their mutual advantage.

In addition, a commitment from Ontario Hydro to purchase uranium from Haliburton area producers would assist in getting development underway.

HALIBURTON AREA URANIUM PROSPECTS



APPENDIX

Madawaska Mining Process

The mining process used at Madawaska is similar to the one described here with minor variations such as use of magnesium for precipitation rather than amonia or hydrogen. More details may be found on Table 6.

Acid Leach, Countercurrent Decantation (CCD), and Solvent Extraction or Fixed Bed Ion Exchange

This process is used when two conditions are met—acid requirements for leaching are reasonable, in terms of acid cost, and thickener area requirements to separate leached ore from the leach solution are reasonable, in terms of capital cost.

The process begins with crushing, followed by wet or dry grinding to a size suitable for leaching (about 35 mesh for sandstone ores). The leaching is conducted in a series of agitated tanks with 8–16 hours retention time for the pulp. An oxidant such as sodium chlorate is usually needed to maximize uranium solubilization. However, pressure leaching is now replacing atmospheric leaching in some cases to reduce the oxidant requirements.

The uranium-bearing leach solution is separated from the solids in a series of countercurrent thickener tanks. Washed solids from the underflow of the last thickener move to a solid waste tailings pond, while the leach solution is clarified, usually by filtration, and the uranium concentrated in a solvent extraction or fixed bed ion exchange circuit.

Ammonia or hydrogen peroxide precipitates uranium from the concentrated solutions, and the precipitate is filtered, dried, and calcined to yellow cake. If the leach liquor contains molybdenum in significant amounts, special provisions may be required to prevent above-specification molybdenum from reporting to the yellow cake product or contaminating the exchanger.

The raffinates from solvent extraction or ion exchange, and solutions from the settled solid waste tailings pond, are recycled to the process stream, evaporated in lined effluent ponds, or both.

Uranium recovery with this method is generally 94-97%, depending on ore grade, with higher grade ore resulting in better recovery. There are now ten operating US mills employing this process with solvent extraction, and two with ion exchange. Thirteen mills, either under construction or in the design phase, have selected the acid leach, CCD process with solvent extraction.

KNOWN URANIUM DEPOSITS IN THE BANCROFT-HALIBURTON AREA Table 1

Company	Type of Deposit	Ore Tonnage	Average Grade %	Uranium Content	
				Tons	Pounds
Amalgamated Rare Earth and Esso Minerals	pegmatite	1,900,000	0.09	1,710	3,420,000
Esso	pegmatite	911,000	.0255	232	464,610
	skarns	500,000	.05	250	500,000
Cam-Kerr Groups	pegmatite	1,000,000	.0625	625	1,250,000
Uranex	pegmatite	2,000,000	.035	70	1,400,000
Total		6,311,000	0.0557	3,517	7,034,610
Total if cutoff grade 1 lb/ton		3,800,000	0.076	2,885	5,770,000

Source: Canadian Mines Handbook, and discussions with company representatives.

MADAWASKA URANIUM MINE, MINING, MILLING AND OTHER COSTS AND REVENUES

Table 2

	($000's)		Revenue/Cost per ton of Ore Milled ($)		Revenue/Cost per ton of Uranium Produced (cost/lb.)	
	1978	1977	1978	1977	1978	1977
SALE REVENUE	21,878	17,500	58.26	59.31	40.00	39.70
Cost of Mining	8,319	6,554	22.15	22.21	15.21	14.87
Cost of Milling	3,069	2,987	8.17	10.12	5.61	6.78
General & Admin.	1,422	1,015	3.79	3.44	2.60	2.30
Interest Expenses	1,135	1,092	3.02	3.70	2.07	2.48
Mining Tax	1,342	655	3.57	2.22	2.45	1.49
TOTAL COSTS	15,288	12,304	40.71	41.70	27.95	27.91
Costs without Interest Charges and Mining Tax	12,811	10,557	34.12	35.78	23.43	23.94

Source: Annual Reports of Consolidated Canadian Faraday Ltd., 1977 and 1978.

MADAWASKA URANIUM MINE,
PRODUCTION DATA, 1977 AND 1978

Table 3

	1978	1977	% Change
Ore Milled (in short tons)	357,533	295,068	21.2
Uranium (in pounds)	546,998	440,753	24.1
Average Grade	0.077%	0.076%	1.3
Average Recovery Rate	95%	95%	–
Uranium Recoverd (per ton ore)	1.53	1.49	2.7
Average Price Realized ($/lb)	40.00	32.20	24.2
Average Ore Milled/day (assume 250 days of operation)	1,430t	1,180t	21.2
No. of days of Full Capacity Utilization	238	197	20.8

Source: Annual Reports of Consolidated Canadian Faraday Ltd., 1977 and 1978.

MADAWASKA URANIUM MINE, BREAKDOWN OF COSTS BY FUNCTION PER TON OF ORE

Table 4

Cost Component	1978			1977		
	A	B	C	A	B	C
	($)	(%)	(%)	($)	(%)	(%)
Mining	22.15	54.4	65.0	22.21	53.3	62.1
Milling	8.17	20.1	23.9	10.12	24.3	28.3
General Admin.	3.79	9.3	11.1	3.44	8.2	9.6
Interest Expenses	3.02	7.4	-	3.70	8.9	-
Mining Tax	3.57	8.7	-	2.22	5.3	-
TOTALS						
All inclusive	40.71	100.0	na	41.69	100.0	na
Excluding Interest and Tax	34.12	na	100.0	35.77	na	100.0

Source: Table 3.

A = Actual cost in dollars per ton of ore.
B = Per cent of total costs.
C = Per cent of total costs without tax or interest charges.

MADAWASKA URANIUM MINE - COST OF OPERATIONS WITHOUT AMORTIZATION COSTS[1] ($)

Table 5

	1978		1977	
	Per Ton	Per Pound	Per Ton	Per Pound
Mining	18.83	12.93	19.06	12.76
Milling	6.95	4.77	8.68	5.82
General & Admin.	3.22	2.21	2.95	1.97
TOTAL	29.00	19.91	30.69	20.55

Source: Table 4 and information obtained from the Annual Report on expenses related to amortization, depreciation and depletion.

1. Costs of amortization, depreciation and deferred charges. applied proportionally to these three functions.

ACID LEACH, COUNTERCURRENT DECANTATION, AND SOLVENT EXTRACTION OR FIXED BED ION EXCHANGE

Table 6

Process Parameters

Leaching:	
Temperature	150°F
Pressure	Atmospheric
Retention Time	12 hours
Sulfuric Acid (2.0¢/lb. cost)	125 lb/ton
Sodium Chlorate	3 lb/ton
Countercurrent Decantation Thickener System (Conventional Type):	
Number of Stages	8
Area Requirements per stage	5 ft/ton/day
Wash ratio (ton solution/ton solids)	2.5
Solid Waste Pond	15-year capacity

Capital and Operating Costs

Plant Capacity Ton Feed/Day	Range of Capital Costs (million dollars)	Cost/Ton of Daily Plant Capacity (thousand dollars)	Average Direct Operating Cost/ Ton Feed dollars
500	9.0-10.5	18.0-21.0	16.00
1,000	14.0-16.0	14.0-16.0	11.80
2,000	23.0-27.0	11.5-13.5	9.70
3,000	30.0-34.5	10.0-11.4	8.70

Source: Robert B. Coleman, "Today's Uranium Milling Costs", Mining Engineering, October 1978.

LIFE OF KNOWN ORE BODIES AND ANNUAL AMORTIZATION COSTS (AAC)

Table 7

		365 days/year Utilization			300 days/year Utilization		
			AAC			AAC	
Capacity tpd	Average Capital Cost ($M)	Life (yrs.)	Total ($M)	Per Ton ($)	Life (yrs.)	Total ($M)	Per Ton ($)
500	9.75	20.8	1.13	6.19	25.0	1.07	7.13
1,000	15.00	10.4	2.38	6.52	13.0	2.11	7.03
1,500	21.00	7.0	4.31	7.87	8.5	3.79	8.40
2,000	25.00	5.2	6.39	8.75	6.3	5.54	9.23
3,000	32.25	3.5	10.37	10.38	4.2	9.78	10.87

Source: Robert B. Coleman, "Today's Uranium Milling Costs", Mining Engineering, October, 1978.

Assumptions:

- Size of all known ore bodies cumulative = 3.80 million tons.
- Average capital cost of 1,500 tpd mill is estimated from tables and text from the source.
- Life of ore is calculated on the basis of the following:

  Life = 3.80 million ÷ (capacity x no. of days of operation/ per yr.)
- Rate of interest is assumed to be 10 percent per annum.
- Cost/ton in dollars at full capacity.

IMPACT OF DECLINING GRADE ON COST PER POUND OF URANIUM

Table 8

Assumptions:

Mill Size:	1,500 tons per day operating 300 days/year
Ore Milled/Year:	450,000 tons
Mining Costs:	$25/ton constant
Milling Costs:	$12/ton constant
Administrative Costs:	$4/ton
Annual Operating Costs:	$18,450,000

Grade %	Uranium Content/ton	Recovery Rate: Percent	Recovery Rate: lbs/ton	Total Uranium Recovered (lbs.)	Recovery Cost Per Pound of Uranium
0.07	1.4 lb.	95	1.33	598,500	30.83
0.06	1.2	93	1.12	502,200	36.74
0.05	1.0	90	0.90	405,000	45.56
0.04	0.8	85	0.68	306,000	60.29
% Change:					
-42.8		-10.5			+95.5

Source: Treasury Estimates, in 1979 dollars.

TABLE 9

ONTARIO HYDRO URANIUM REQUIREMENTS AND CONTRACTED SUPPLY.

Ontario Hydro's Forecasted Requirements		Contracted Supply	Surplus (deficit)
		(in Tonnes of Uranium)	
1979	940	1200	260
1980	625	925	300
1981	1025	875	(150)
1982	1025	1050	25
1983	1200	1525	325
1984	1200 - 1350	1850	575
1985	1200 - 1500	1800	550
1986	1500 - 1750	1550	(75)
1987	1700 - 1875	1525	(265)
1988	1775 - 2025	1525	(375)
1989	2000	1525	(475)
1990	2000	1525	(475)
1991	2250	1550	(700)
1992	2325	1625	(700)
1993	2450	1625	(825)
1994	2550	3250	700
1995	2750	3300	550
1996	3025	3200	175
1997	3400	3125	(275)
1998	3400	3125	(275)
	38805	37675	1130

Source: Ontario Hydro, *1979 Review* of Generation *Expansion Program*, March 1979

(Read from Graph in our text Graph 2)

TABLE 10

ANNUAL URANIUM PRODUCTION AND THE LIFE OF KNOWN DEPOSITS IN THE HALIBURTON AREA

Mill Capacity tpd	1000		1500	
Annual Production & Life of deposits of Mill operating	U_3O_8 000 lbs.	Life yrs.	U_3O_8 000 lbs.	Life yrs.
200 days/yr	289	19	433	12.7
250 days/yr	361	15.2	541	10.1
300 days/yr	433	12.7	650	8.4
350 days/yr	505	10.9	758	7.2

Assumptions

- 1.52 lbs. of U_3O_8 per ton and recovery rate 95%. No preconcentration by use of radiametric ore sorting.
- 5.77 million lbs. of U_3O_8 contained in 3.8 million tons of ore in the area.

TABLE 11

WORLD'S REACTORS IN OPERATION AND UNDER CONSTRUCTION

	Power plants completed			Under construction		
	Qty.	Type	Total MW (net)	Qty.	Type	Total MW (net)
Argentina	1	PHWR	319	1	PHWR	600
Austria	1	BWR	692	—	—	—
Belgium	3	PWR	1,660	4	PWR	3,825
Brazil	—	—	—	2	PWR	1,871
Bulgaria	2	PWR	880	2	PWR	880
Canada	1	BLWR	250	15	PHWR	10,794
	8	PHWR	4,761			
	9		5,011			
Czechoslovakia	1	HWGCR	110	4	PWR	1,760
Finland	1	PWR	420	1	PWR	420
	1	BWR	660	1	BWR	660
	2		1,080	2		1,080
France	1	FBR	233	1	FBR	1,200
	1	HWGCR	70	21	PWR	20,085
	9	PWR	7,510	22		21,285
	5	GCR	2,125			
	16		9,938			
Germany Democratic Republic	4	PWR	1,390	3	PWR	1,320
Germany Federal Republic	1	PHWR	52	1	LMFBR	295
	6	BWR	3,638	2	BWR	2,498
	5	PWR	4,538	3	PWR	3,802
	12		8,228	6		6,595
Hungary	—	—	—	4	PWR	1,760
India	1	PHWR	202	5	PHWR	1,082
	2	BWR	400			
	3		602			
Iran	—	—	—	2	PWR	2,400
Italy	1	GCR	150	2	BWR	1,964
	2	BWR	990			
	1	PWR	247			
	4		1,387			
Japan	1	LWCHW	200	3	BWR	2,634
	10	BWR	6,645	4	PWR	3,311
	7	PWR	4,197	7		5,945
	13		11,042			
Korea	1	PWR	564	3	PWR	2,405
				1	PHWR	629
				4		3,034
Mexico	—	—	—	2	BWR	1,308
Netherlands	1	BWR	50	—	—	—
	1	PWR	443			
	2		493			
Pakistan	1	PHWR	125	—	—	—
Phillipines	1	PWR	620	—	—	—
South Africa	—	—	—	2	PWR	1,844
Spain	1	GCR	480	1	BWR	930
	1	BWR	440	6	PWR	5,542
	2	PWR	1,053	7		6,472
	4		1,973			
Sweden	2	PWR	1,700	1	BWR	900
	6	BWR	3,800	1	PWR	900
	8		5,500	2		1,800
Switzerland	1	BWR	320	1	BWR	955
	2	PWR	700	1	PWR	920
	3		1,020	2		1,875
Taiwan	1	BWR	604	3	BWR	2,506
				2	PWR	1,814
				5		4,320
United Kingdom	26	GCR	5,206	6	AGR	4,325
	1	HWLWR	92			
	1	LMFBR	250			
	4	AGR	2,500			
	32		8,048			
United States	43	PWR	33,026	60	PWR	66,401
	25	BWR	17,755	26	BWR	28,093
	1	HTGR	330	86		94,494
	1	LGR	860			
	70		55,971			
USSR	12	LGR	4,900			
	9	PWR	3,575			
	1	BWR	50			
	1	LMFBR	350			
	23		8,875			
Yugoslavia	—	—	—	1	PWR	615

Abbreviations

AGR — Advanced gas-cooled reactor
BLWR — Boiling light water reactor
BWR — Same as BLWR
FBR — Fast breeder reactor
GCR — Gas-cooled reactor
LGR — Light-water cooled, graphite-moderated reactor
HTGR — High-temperature, gas-cooled reactor
HWGCR — Heavy-water-moderated gas-cooled reactor
HWLWR — Heavy-water-moderated light-water-cooled reactor
LMFBR — Liquid metal fast breader reactor
PHWR — Pressurized heavy-water-moderated-and-cooled reactor
PWR — Pressurized light water reactor

Source: Nuclear News, February 1979

TABLE 12

HALIBURTON POPULATION AND LABOUR FORCE BY AGE, 1978 ESTIMATES

Age	Male Pop	Male LF	Female Pop	Female LF	Total Pop	Total LF
15-19	521	255	476	176	997	431
20-24	404	358	356	206	760	564
25-34	634	578	625	284	1,259	862
35-44	515	481	520	289	1,035	770
45-54	580	487	546	248	1,126	735
55-64	559	370	660	191	1,219	561
65+	789	117	875	71	1,664	188
Total	4,002	2,646	4,058	1,465	8,060	4,111

Source: Population - Treasury Estimates.
Labour Force - Derived from labour force participation rates, 1976 Census.

Total Available Labour Force:

	Labour Force	Employment	Haliburton Unemployment	Ontario Unemployment
1976	4,245	3,955	6.8%	6.2%
1978	4,111	3,786	7.9%	7.2%

∴ Available labour force = 325.

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